



# EDGEWOOD

CHEMICAL BIOLOGICAL CENTER

U.S. ARMY SOLDIER AND BIOLOGICAL CHEMICAL COMMAND

ECBC-TR-007

DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
SARIN CHALLENGE/VAPOR PENETRATION SWATCH TESTING  
OF TYCHEM 10000 VAPOR PROTECTIVE SUIT  
MODEL 11645

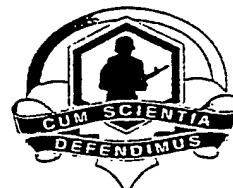
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February 1999

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Aberdeen Proving Ground, MD 21010-5424

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## Preface

The work described in this report was authorized under the Expert Assistance (Personal Protective Equipment Evaluation) Program for the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* Program Director for Domestic Preparedness. The work was started in January 1998 and completed in March 1998.

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\* Now known as the U.S. Army Edgewood Chemical Biological Center (ECBC).

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## CONTENTS

1.	INTRODUCTION.....	7
2.	MATERIALS AND METHODS.....	7
2.1	Suit Description.....	7
2.2	Swatch Preparation.....	7
2.3	Test Procedure.....	9
3.	RESULTS AND DISCUSSION.....	11
3.1	HD Results.....	11
3.2	GB Results.....	11
3.3	Material Thickness.....	12
APPENDIXES		
	A-MODIFIED STATIC DIFFUSION PROCEDURE.....	13
	B-HD TABLES.....	15
	C-GB TABLES.....	23

## **FIGURES**

1	Tychem 10000 Label.....	8
2	TOP Permeation Cell.....	9
3	Environmental Cabinet.....	10
4	MINICAMS and Stream Selection System.....	10

**DOMESTIC PREPAREDNESS PROGRAM: LIQUID SULFUR MUSTARD AND  
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MODEL 11645**

**1. INTRODUCTION**

Under the Domestic Preparedness (DP) Expert Assistance (Personal Protective Equipment (PPE) Evaluation) Program, the U. S. Army Edgewood Research, Development and Engineering Center (ERDEC)\* was tasked to perform testing of swatches taken from commercially-available Level A suits currently being used by emergency responders from cities involved in this program. The testing was performed by the Design Evaluation Group, Surety Team, Methodology, Instrumentation and Test Office, Engineering Directorate. The test procedure was jointly developed and agreed upon by ERDEC and the U. S. Army Natick, Research, Development and Engineering Center (NRDEC) (written communication, M. Chin, NRDEC, 1 May 97).

**2. MATERIALS AND METHODS**

**2.1 Suit Description.**

The Tychem 10000 suit was manufactured by Lakeland Industries, (Somerville, AL) and was bright yellow-green in color. The model number was 11645. Figure 1 is a digital photograph of the label found inside the suit.

**2.2 Swatch Preparation.**

The day before testing was scheduled to begin, the suit was picked up from Mask Issue and transported to the laboratory. The suit was folded up for transport and was hung on a hanger once in the laboratory. The suit was stored this way during and after testing.

The swatch locations to be sampled were given in the PPE Test Team Work Contract for Level A Ensembles (written communication, R. Belmonte, Engineering Directorate, ERDEC, 25 June 1997). These swatch sampling locations were listed as suit material (SM), suit seam (SS), visor material (VM), zipper/suit material seam (ZP), glove (GL), and visor material/suit material seam (SV). The suit pass through could not be sampled because it could not be made flat to fit in a permeation cell. The swatches were normally cut the day before testing and conditioned overnight at the test conditions. For a Monday test, swatches were cut Friday and conditioned over the weekend. Normally, the swatches would be laid in the environmental cabinet for conditioning.

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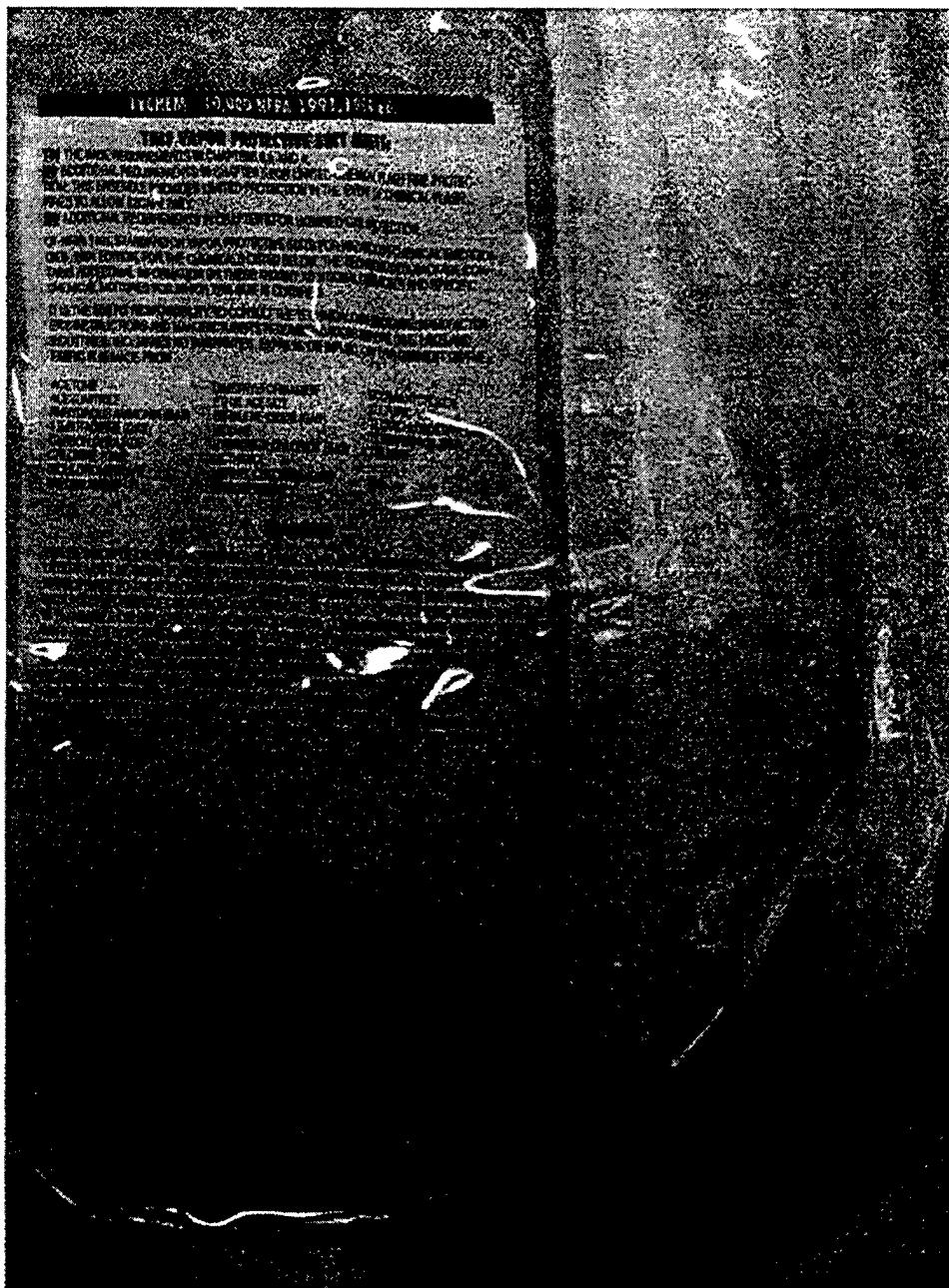


Figure 1. Tychem 10000 Label

The swatches were numbered in accordance with the PPE Test Team Work Instructions (written communication, R. Belmonte, Engineering Directorate, ERDEC, 11 June 1997); for example LC-TYC-SM-01, etc. All swatches were cut in triplicate, one at a time on a sample press. The swatch diameter was 2 in.

The reference material was 80-mil silicone, using the M45 mask formulation, prepared by Malcolm Little of the M45 mask team. Preparation and conditioning were the same as for the suit swatches.

## 2.3

### Test Procedure.

The procedure agreed upon by ERDEC and NRDEC was derived from the report entitled, "Permeation and Penetration Testing of Air Permeable, Semi-permeable and Impermeable Materials with Chemical Agents or Simulants (Swatch Testing)" dated 3 March 1997. The Modified Static Diffusion Procedure is found in Appendix A of this report. Subsequent to the agreement, ERDEC personnel determined that the usage of the 80-mil silicone did not meet the definition of a positive control. The silicone swatches were used as an indication of agent vapor permeation. Equipment and schedule limitations prevented the use of negative controls. The terminology of the test procedure was not modified to reflect these changes.

The TOP permeation cell was used and a digital photograph of one is given as Figure 2.

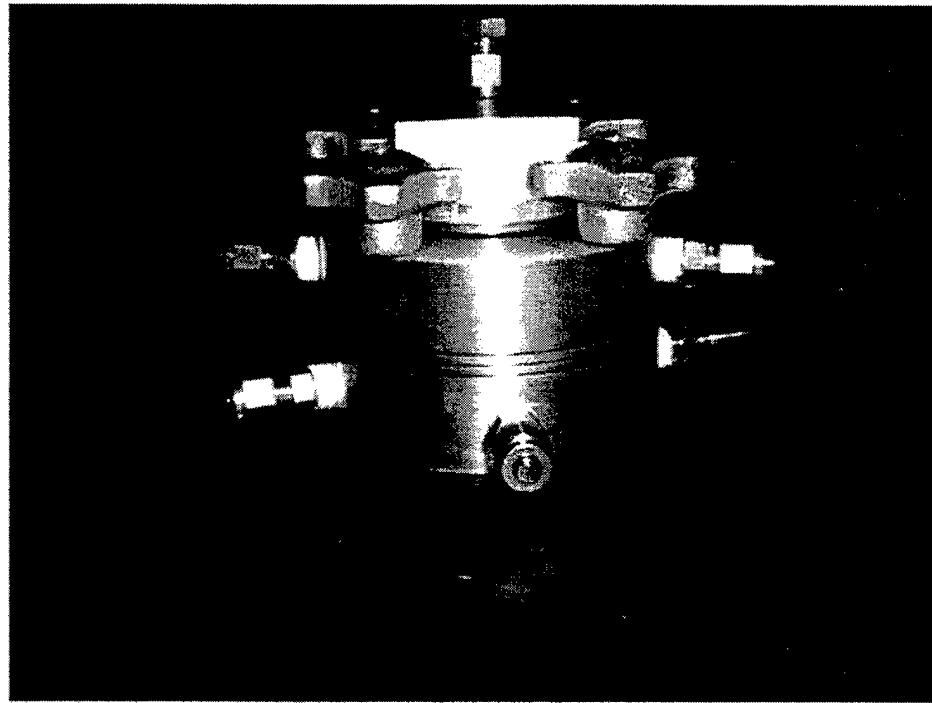


Figure 2. TOP Permeation Cell

The remainder of the test apparatus consisted of the following.

- Plastic environmental cabinet with sliding doors containing a permeation cell rack, circulating blower, and heat source (Figure 3).
- Flow/temperature/relative humidity control system; (Miller-Nelson Research Corporation, Monterey, CA) model HCS-410.

- Flow control system; (Tylan General Incorporated, Torrance, CA) Dynamass model FM-8.
- Mass flow controllers; (Tylan General Incorporated, Torrance, CA) model FC-260.
- Calibrated Vaisala humidity and temperature indicator.
- MINICAMS, serial number 2362, and Stream Selection System (CMS Research Corporation, Birmingham, AL), illustrated in Figure 4.

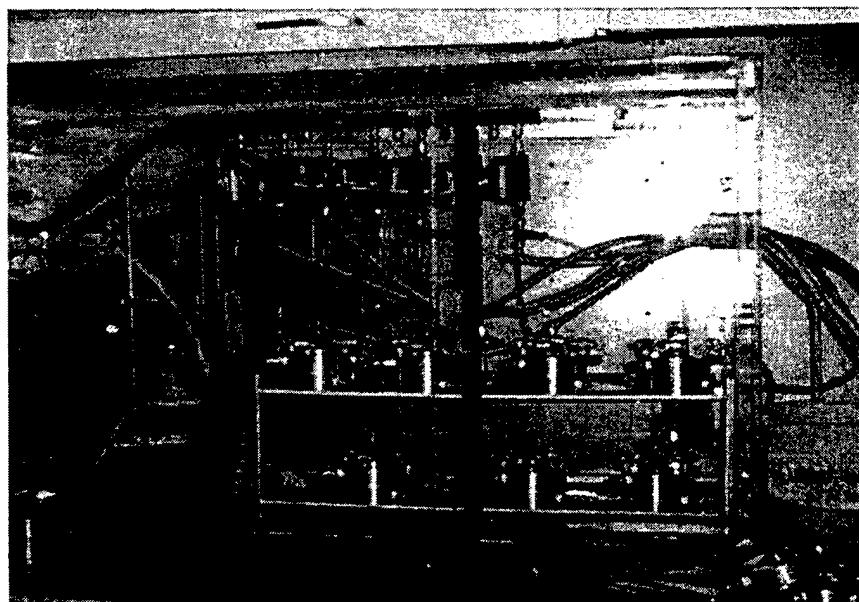


Figure 3. Environmental Cabinet

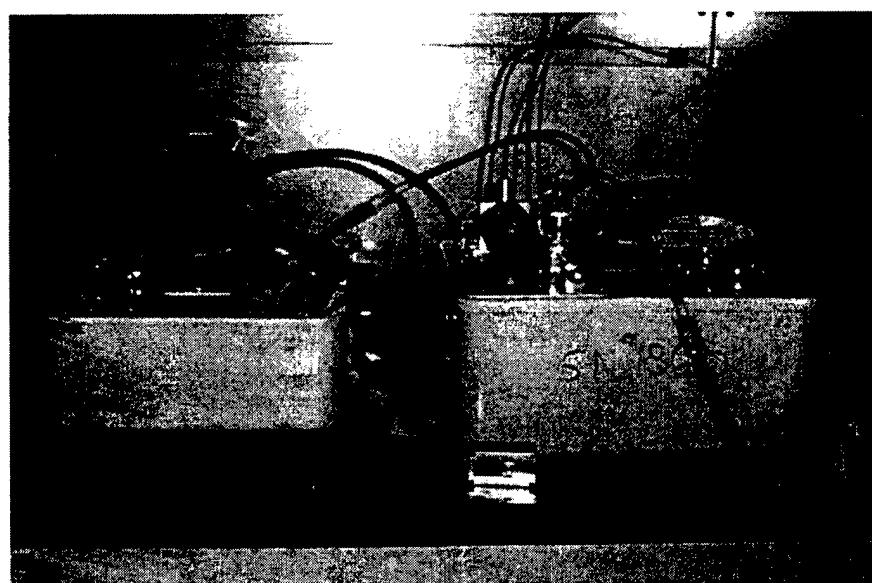


Figure 4. MINICAMS and Stream Selection System

### 3. RESULTS AND DISCUSSION

#### 3.1 HD Results.

The HD permeation results are given in Appendix B as Tables B-1 through B-6. Average elapsed time was not used. The actual time that each swatch was sampled by the MINICAMS is shown.

The MINICAMS minimum detection limit was 1.0 ng for all test days. There were no visible effects on any of the materials from HD exposure. Cumulative permeation for all swatches was similar to or less than that for the suit material.

The average temperature was 97.6 °F, and 18.1% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

#### 3.2 GB Results.

The GB permeation results are given in Appendix C as Tables C-1 through C-6.

The MINICAMS minimum detection limit was 0.4 ng for all test days. There were no visible effects on any of the materials from GB exposure. Cumulative permeation was highest for the zipper/material interface and one suit/visor interface swatch (over ten times higher than for the suit material).

The average temperature was 94.1 °F and 20.8% RH was the average for all tests. Test temperatures were greater than 90 °F due to a malfunction in the laboratory heating system, which caused the room temperature to be elevated, and the lack of a cooling capability in the test apparatus. The first MINICAMS cycle for each swatch was taken before agent was applied. This cycle served as an indication that no agent vapor was present prior to the start of the test. Negative control and positive control swatches were not used due to budget and schedule limitations.

### 3.3

#### Material Thickness.

After the HD and GB testing was completed, thickness measurements of the suit material, visor material, and glove material were made. A swatch of material was cut from the suit immediately adjacent to the area from which the agent swatches were taken. Twenty-four thickness measurements were taken on each swatch using an Ames dial comparator (B. C. Ames Company, Waltham, MA). The average thickness of the suit material swatch was 0.038 in., the visor material swatch was 0.032 in., and the glove swatch was 0.021 in.

**APPENDIX A**  
**MODIFIED STATIC DIFFUSION PROCEDURE**

## MODIFIED STATIC DIFFUSION TEST

This test procedure was adapted from the "Semipermeable and Impermeable Materials Static Diffusion Penetration Testing (Liquid Agent Challenge/Vapor Penetration; delta p = 0, Single Flow Test) given in Test Operations Procedure (TOP) 8-2-501 dated 3 Mar 97.

The following procedure will be used:

Upon receipt of a suit, all available information concerning the suit will be recorded; date of manufacture, lot number, serial number, materials of construction, etc.

From each suit, 3 ea 1 and 15/16 in. diameter material swatches will be taken for HD and a like number taken for GB. Depending upon the suit configuration, three seam swatches (same diameter) will be taken plus triplicate swatches of other flat components such as other seams, visor, gloves, booties, etc. for HD and an equal number for GB. Each swatch will be placed in an airtight bag and given a unique serial number which will be placed on the bag. A list of serial numbers will be kept with the swatches.

The environmental chamber will be controlled at a temperature of 90 +/- 2 °F, and the maximum achievable RH without occurrence of condensation (70% +/- 10% RH). The temperature and RH readings will be checked weekly with a calibrated meter. The test cell air will be drawn from the chamber air. There will be no system control and data acquisition system. The temperature and RH will be recorded in a computer file. Flow rates will be manually recorded. There will be no differential pressure monitoring since differential pressure gages of sufficient sensitivity are not available.

The TOP test cell will be used. When assembling, the cell lugs will be tightened by hand to finger tight. The flow rate beneath each swatch will be 1 L/min which will be controlled by a linear mass flow controller. The flows will be checked with a calibrated test meter weekly. Each test cell will be checked for leaks after assembly by connecting it to the vacuum source and checking that the inlet flow is the same as the outlet flow on the mass flow controller (cell lugs will be retightened if flows don't match).

The samples will serve as their own negative controls while being preconditioned overnight by being MINICAMS monitored. Eighty mil silicone will be used as a positive control for each test (six suit swatches and one silicone swatch).

Agents GB and HD will be used. The contamination density will be 10 g/m<sup>2</sup> (eight each 1 µl HD droplets or ten each 1 µl GB droplets). A robotic agent application system is not available. The agent will be applied using the click/touch method with a Hamilton repeating dispenser.

Seven swatches will be tested at once. MINICAMS with stream selection system will monitor vapor penetration with a 3-min cycle. There will be three blank sampling intervals following the control. Each swatch will be sampled once every 30 min. The MINICAMS will be standardized weekly.

The test length will be 24 hr.

The test cells and o-rings will be aerated between uses. No other cleaning method will be used.

The data to be reported are cumulative penetration (ng/cm<sup>2</sup>) versus average elapsed time (minutes) for each swatch. The average elapsed time is the sum of the elapsed time for swatch 1 and the elapsed time for swatch 6 divided by 2. All recorded data will be placed in laboratory notebooks and a technical report will be drafted at the conclusion of this effort.

For entry into the DP database, the data for each swatch will be reported as cumulative penetration for the first four sampling intervals (approximately 12, 42, 72, and 102 min), and at approximately 6, 12, 18, and 24 hr.

Appendix A

**APPENDIX B**

**HD TABLES**

Table B-1. Tychem 10000 Suit Material vs. HD Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 12 Feb 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	3	0	6	2
30	0	33	0	36	24
60	0	63	0	66	49
90	0	93	0	96	75
120	2	123	0	126	105
150	8	153	2	156	135
180	15	183	7	186	166
210	23	213	13	216	196
240	31	243	18	246	226
270	39	273	23	276	256
300	47	303	29	306	285
330	55	333	34	336	312
360	62	363	39	366	339
390	69	393	44	396	366
420	76	423	48	426	391
450	83	453	53	456	415
480	89	483	57	486	437
510	95	513	61	516	460
540	101	543	65	546	482
570	107	573	69	576	504
600	112	603	71	606	525
630	117	633	71	636	546
660	122	663	71	666	567
690	127	693	71	696	588
720	132	723	71	726	608
750	134	753	71	756	628
780	137	783	71	786	647
810	139	813	71	816	667
840	139	843	71	846	687
870	139	873	71	876	706
900	139	903	71	906	726
930	139	933	71	936	745
960	139	963	71	966	764
990	139	993	71	996	784
1020	139	1023	71	1026	804
1050	139	1053	71	1056	823
1080	139	1083	71	1086	843
1110	139	1113	71	1116	862
1140	139	1143	71	1146	881
1170	139	1173	71	1176	900
1200	139	1203	71	1206	920
1230	139	1233	71	1236	940
1260	139	1263	71	1266	960
1290	139	1293	71	1296	981
1320	139	1323	71	1326	1001
1350	139	1353	71	1356	1022
1380	139	1383	71	1386	1043
1410	139	1413	71	1416	1065

**Table B-2. Tychem 10000 Suit Seam vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 12 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
9	0	12	0	15	0
39	0	42	0	45	0
69	0	72	0	75	0
99	0	102	0	105	0
129	2	132	0	135	0
159	7	162	0	165	0
189	13	192	0	195	0
219	18	222	2	225	0
249	24	252	6	255	0
279	30	282	10	285	0
309	36	312	12	315	0
339	41	342	12	345	0
369	46	372	12	375	0
399	51	402	12	405	0
429	57	432	12	435	0
459	62	462	12	465	0
489	66	492	12	495	0
519	71	522	12	525	0
549	75	552	12	555	0
579	80	582	12	585	0
609	84	612	12	615	0
639	88	642	12	645	0
669	92	672	12	675	0
699	97	702	12	705	0
729	99	732	12	735	0
759	99	762	12	765	0
789	99	792	12	795	0
819	99	822	12	825	0
849	99	852	12	855	0
879	99	882	12	885	0
909	99	912	12	915	0
939	99	942	12	945	0
969	99	972	12	975	0
999	99	1002	12	1005	0
1029	99	1032	12	1035	0
1059	99	1062	12	1065	0
1089	99	1092	12	1095	0
1119	99	1122	12	1125	0
1149	99	1152	12	1155	0
1179	99	1182	12	1185	0
1209	99	1212	12	1215	0
1239	99	1242	12	1245	0
1269	99	1272	12	1275	0
1299	99	1302	12	1305	0
1329	99	1332	12	1335	0
1359	99	1362	12	1365	0
1389	99	1392	12	1395	0
1419	99	1422	12	1425	0

**Table B-3. Tychem 10000 Glove Material vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 4 Mar 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	1	7	0
31	3	34	8	37	0
61	3	64	15	67	0
91	3	94	23	97	0
121	5	124	32	127	0
151	11	154	42	157	3
181	19	184	55	187	9
211	30	214	69	217	16
241	42	244	84	247	23
271	55	274	100	277	32
301	69	304	116	307	41
331	83	334	133	337	50
361	97	364	150	367	59
391	110	394	167	397	68
421	124	424	183	427	77
451	137	454	199	457	86
481	150	484	215	487	95
511	162	514	230	517	104
541	174	544	245	547	112
571	186	574	259	577	120
601	197	604	272	607	127
631	207	634	285	637	135
661	218	664	298	667	142
691	227	694	310	697	149
721	237	724	323	727	155
751	246	754	334	757	162
781	254	784	345	787	168
811	263	814	356	817	174
841	271	844	366	847	180
871	279	874	377	877	186
901	286	904	387	907	191
931	294	934	396	937	197
961	301	964	405	967	202
991	308	994	414	997	207
1021	314	1024	423	1027	212
1051	320	1054	431	1057	217
1081	326	1084	439	1087	219
1111	332	1114	447	1117	219
1141	338	1144	455	1147	219
1171	343	1174	462	1177	219
1201	348	1204	470	1207	219
1231	353	1234	477	1237	219
1261	358	1264	484	1267	219
1291	363	1294	491	1297	219
1321	367	1324	497	1327	219
1351	372	1354	504	1357	219
1381	375	1384	511	1387	219
1411	375	1414	518	1417	219

**Table B-4. Tychem 10000 Zipper/Material Interface vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 4 Mar 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	1
40	0	43	0	46	4
70	0	73	0	76	4
100	0	103	0	106	7
130	0	133	0	136	12
160	0	163	0	166	18
190	3	193	2	196	25
220	9	223	8	226	33
250	16	253	13	256	42
280	23	283	20	286	51
310	31	313	27	316	61
340	40	343	34	346	70
370	49	373	42	376	80
400	59	403	50	406	90
430	69	433	58	436	101
460	79	463	66	466	111
490	90	493	75	496	121
520	102	523	84	526	132
550	114	553	93	556	142
580	126	583	103	586	153
610	139	613	112	616	163
640	152	643	122	646	173
670	166	673	132	676	184
700	180	703	143	706	194
730	195	733	153	736	204
760	210	763	164	766	215
790	226	793	175	796	225
820	242	823	187	826	235
850	259	853	199	856	246
880	278	883	211	886	256
910	298	913	224	916	267
940	319	943	236	946	278
970	340	973	249	976	289
1000	362	1003	262	1006	299
1030	384	1033	276	1036	310
1060	408	1063	290	1066	321
1090	432	1093	304	1096	332
1120	457	1123	318	1126	342
1150	482	1153	332	1156	353
1180	508	1183	347	1186	364
1210	534	1213	361	1216	375
1240	560	1243	376	1246	386
1270	586	1273	391	1276	397
1300	613	1303	407	1306	409
1330	641	1333	423	1336	420
1360	671	1363	441	1366	432
1390	703	1393	460	1396	444
1420	737	1423	481	1426	457

## Appendix B

Table B-5. Tychem 10000 Visor Material vs. HD Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 3 Mar 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
31	10	34	14	37	5
61	19	64	27	67	9
91	19	94	27	97	9
121	19	124	30	127	12
151	22	154	36	157	17
181	30	184	43	187	23
211	40	214	52	217	31
241	50	244	62	247	39
271	61	274	72	277	47
301	73	304	82	307	55
331	85	334	93	337	64
361	97	364	103	367	73
391	109	394	114	397	82
421	121	424	125	427	91
451	133	454	135	457	100
481	145	484	146	487	109
511	157	514	157	517	118
541	169	544	167	547	127
571	180	574	177	577	135
601	191	604	187	607	144
631	202	634	197	637	152
661	212	664	206	667	160
691	222	694	215	697	167
721	232	724	224	727	175
751	241	754	233	757	182
781	250	784	241	787	189
811	259	814	249	817	196
841	267	844	257	847	203
871	275	874	265	877	209
901	283	904	272	907	216
931	291	934	279	937	222
961	298	964	286	967	228
991	305	994	293	997	234
1021	312	1024	300	1027	239
1051	319	1054	306	1057	245
1081	325	1084	312	1087	250
1111	331	1114	318	1117	255
1141	337	1144	324	1147	260
1171	343	1174	329	1177	265
1201	349	1204	335	1207	270
1231	354	1234	340	1237	275
1261	360	1264	346	1267	277
1291	365	1294	351	1297	277
1321	370	1324	356	1327	277
1351	375	1354	361	1357	279
1381	380	1384	366	1387	281
1411	385	1414	371	1417	281

**Table B-6. Tychem 10000 Suit/Visor Interface vs. HD Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 3 Mar 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	16	0
40	0	43	0	46	0
70	0	73	0	76	0
100	0	103	0	106	0
130	0	133	0	136	0
160	0	163	0	166	0
190	3	193	3	196	0
220	8	223	8	226	3
250	14	253	14	256	8
280	20	283	20	286	13
310	27	313	26	316	19
340	34	343	33	346	24
370	41	373	39	376	30
400	48	403	46	406	36
430	55	433	53	436	43
460	62	463	60	466	49
490	70	493	67	496	55
520	77	523	74	526	62
550	84	553	81	556	68
580	91	583	88	586	74
610	97	613	95	616	80
640	104	643	101	646	86
670	110	673	108	676	92
700	117	703	114	706	98
730	123	733	120	736	104
760	129	763	126	766	109
790	134	793	132	796	115
820	140	823	138	826	120
850	145	853	143	856	126
880	151	883	149	886	131
910	156	913	154	916	136
940	161	943	160	946	141
970	166	973	165	976	146
1000	171	1003	170	1006	151
1030	176	1033	175	1036	156
1060	178	1063	180	1066	161
1090	178	1093	184	1096	163
1120	178	1123	187	1126	163
1150	178	1153	187	1156	163
1180	178	1183	187	1186	163
1210	178	1213	187	1216	163
1240	178	1243	187	1246	163
1270	178	1273	187	1276	163
1300	178	1303	187	1306	163
1330	178	1333	187	1336	163
1360	178	1363	187	1366	163
1390	178	1393	187	1396	163
1420	178	1423	187	1426	167

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**APPENDIX C**  
**GB TABLES**

Table C-1. Tychem 10000 Suit Material vs. GB Liquid, 10 g/m<sup>2</sup>

Modified Static Diffusion Test, 25 Feb 98

Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
1	0	4	0	7	0
32	15	35	16	38	19
62	67	65	69	68	74
92	142	95	144	98	145
122	215	125	215	128	214
152	281	155	276	158	273
182	338	185	316	188	313
213	379	216	339	219	336
243	408	246	362	249	358
273	432	276	381	279	377
303	454	306	398	309	394
333	474	336	414	339	409
363	492	366	429	369	423
394	510	397	444	400	436
424	527	427	457	430	449
454	544	457	471	460	462
484	559	487	483	490	474
514	574	517	495	520	485
544	589	547	507	550	496
575	604	578	518	581	507
605	617	608	529	611	517
635	630	638	539	641	527
665	644	668	549	671	536
695	656	698	559	701	545
725	668	728	568	731	554
756	679	759	577	762	563
786	691	789	587	792	572
816	702	819	596	822	581
846	712	849	604	852	589
876	723	879	613	882	597
906	733	909	621	912	605
937	743	940	630	943	612
967	753	970	638	973	620
997	762	1000	645	1003	627
1027	771	1030	653	1033	634
1057	781	1060	660	1063	641
1087	789	1090	668	1093	648
1118	798	1121	675	1124	654
1148	807	1151	682	1154	661
1178	815	1181	689	1184	667
1208	823	1211	696	1214	673
1238	830	1241	702	1244	679
1268	838	1271	708	1274	685
1299	846	1302	715	1305	692
1329	854	1332	722	1335	698
1359	861	1362	729	1365	704
1389	869	1392	736	1395	711
1419	880	1422	743	1425	717

Table C-2. Tychem 10000 Suit Seam vs. GB Liquid, 10 g/m<sup>2</sup>  
 Modified Static Diffusion Test, 25 Feb 98  
 Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
10	0	13	0	17	0
41	23	44	27	47	29
71	84	74	90	77	97
101	159	104	163	107	172
131	228	134	231	137	240
161	287	164	290	167	299
191	321	194	327	198	339
222	339	225	348	228	363
252	361	255	370	258	385
282	380	285	389	288	405
312	396	315	404	318	421
342	411	345	419	348	437
372	425	375	432	379	452
403	439	406	445	409	466
433	452	436	458	439	480
463	464	466	469	469	493
493	476	496	481	499	506
523	488	526	492	529	519
553	499	556	503	560	530
584	510	587	513	590	542
614	520	617	523	620	553
644	530	647	533	650	564
674	540	677	542	680	574
704	549	707	551	710	584
734	558	737	560	741	594
765	568	768	569	771	604
795	577	798	578	801	614
825	586	828	586	831	624
855	594	858	594	861	633
885	602	888	602	891	642
915	611	918	610	922	651
946	619	949	617	952	660
976	626	979	625	982	669
1006	634	1009	632	1012	677
1036	641	1039	638	1042	686
1066	648	1069	645	1072	694
1096	655	1099	652	1103	701
1127	662	1130	659	1133	709
1157	669	1160	665	1163	716
1187	675	1190	671	1193	724
1217	682	1220	677	1223	731
1247	688	1250	683	1253	738
1277	694	1280	689	1284	746
1308	701	1311	696	1314	754
1338	708	1341	703	1344	761
1368	714	1371	709	1374	769
1398	721	1401	715	1404	776
1428	727	1431	721	1434	782

Appendix C

**Table C-3. Tychem 10000 Glove Material vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 26 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
2	0	5	1	8	1
33	6	36	5	39	6
63	6	66	5	69	6
93	9	96	8	99	6
123	16	126	14	129	9
153	27	156	22	159	15
183	40	186	32	189	23
214	58	217	46	220	34
244	80	247	65	250	48
274	107	277	87	280	64
304	135	307	110	310	82
334	164	337	135	340	101
364	195	367	160	370	121
395	225	398	186	401	141
425	256	428	211	431	161
455	285	458	236	461	181
485	315	488	260	491	200
515	343	518	284	521	218
545	370	548	306	551	236
576	396	579	328	582	253
606	422	609	349	612	271
636	448	639	371	642	288
666	474	669	392	672	305
696	499	699	413	702	321
726	524	729	434	732	337
757	548	760	453	763	353
787	572	790	473	793	368
817	595	820	492	823	384
847	618	850	511	853	398
877	640	880	528	883	412
907	662	910	547	913	426
938	685	941	566	944	442
968	707	971	584	974	456
998	729	1001	603	1004	471
1028	750	1031	622	1034	485
1058	772	1061	640	1064	500
1088	792	1091	658	1094	514
1119	813	1122	675	1125	527
1149	832	1152	692	1155	540
1179	851	1182	708	1185	553
1209	868	1212	723	1215	564
1239	885	1242	738	1245	575
1269	902	1272	752	1275	587
1300	919	1303	767	1306	598
1330	936	1333	781	1336	609
1360	953	1363	794	1366	620

**Appendix C**

Table C-4. Tychem 10000 Zipper/Material Interface vs. GB Liquid, 10 g/m<sup>2</sup>  
 Modified Static Diffusion Test, 26 Feb 98  
 Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
11	2	14	3	17	4
42	10	45	12	48	91
72	17	75	17	78	315
102	33	105	23	108	615
132	78	135	34	138	929
162	169	165	57	168	1247
192	328	195	96	198	1566
223	562	226	155	229	1879
253	839	256	237	259	2188
283	1129	286	342	289	2497
313	1424	316	470	319	2806
343	1723	346	621	349	3112
373	2026	376	791	379	3421
404	2332	407	979	410	3734
434	2640	437	1182	440	4050
464	2949	467	1397	470	4368
494	3258	497	1616	500	4696
524	3569	527	1837	530	5034
554	3882	557	2058	560	5364
585	4193	588	2279	591	5687
615	4504	618	2502	621	6018
645	4815	648	2728	651	6357
675	5126	678	2953	681	6698
705	5438	708	3180	711	7040
735	5750	738	3415	741	7383
766	6064	769	3655	772	7727
796	6381	799	3889	802	8069
826	6696	829	4122	832	8411
856	7012	859	4355	862	8752
886	7329	889	4589	892	9093
916	7645	919	4822	922	9435
947	7962	950	5055	953	9779
977	8277	980	5294	983	10122
1007	8591	1010	5535	1013	10465
1037	8909	1040	5770	1043	10807
1067	9227	1070	6000	1073	11147
1097	9545	1100	6228	1103	11489
1128	9863	1131	6457	1134	11831
1158	10180	1161	6683	1164	12173
1188	10496	1191	6900	1194	12514
1218	10811	1221	7113	1224	12852
1248	11124	1251	7327	1254	13187
1278	11436	1281	7538	1284	13519
1309	11743	1312	7744	1315	13849
1339	12048	1342	7952	1345	14177
1369	12353	1372	8164		

Appendix C

**Table C-5. Tychem 10000 Visor Material vs. GB Liquid, 10 g/m<sup>2</sup>**  
**Modified Static Diffusion Test, 24 Feb 98**  
**Cumulative Penetration (ng/cm<sup>2</sup>)**

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
11	0	14	0	17	0
41	8	44	18	47	10
71	30	74	44	77	29
101	62	104	64	107	47
131	100	134	86	137	66
161	141	164	109	167	85
191	182	194	132	197	104
221	223	224	153	227	121
251	263	254	175	257	139
281	300	284	193	287	153
311	334	314	208	317	164
341	367	344	223	347	174
371	401	374	239	377	187
401	436	404	257	407	202
431	471	434	275	437	216
461	505	464	292	467	231
491	539	494	309	497	244
521	571	524	326	527	258
551	603	554	341	557	270
581	633	584	357	587	283
611	663	614	372	617	295
641	692	644	387	647	306
671	720	674	400	677	316
701	747	704	414	707	327
731	774	734	427	737	337
761	800	764	439	767	347
791	825	794	451	797	357
821	850	824	463	827	367
851	874	854	474	857	376
881	897	884	485	887	385
911	920	914	496	917	394
941	943	944	507	947	402
971	966	974	518	977	411
1001	987	1004	528	1007	419
1032	1009	1035	538	1038	427
1062	1030	1065	548	1068	435
1092	1050	1095	557	1098	443
1122	1070	1125	567	1128	451
1152	1090	1155	576	1158	458
1182	1109	1185	585	1188	465
1213	1128	1216	594	1219	472
1243	1147	1246	603	1249	479
1273	1166	1276	612	1279	485
1303	1183	1306	620	1309	492
1333	1201	1336	628	1339	498
1363	1219	1366	636	1369	504
1394	1236	1397	644	1400	510
1424	1253	1427	652	1430	516

Table C-6. Tychem 10000 Suit/Visor Interface vs. GB Liquid, 10 g/m<sup>2</sup>  
 Modified Static Diffusion Test, 24 Feb 98  
 Cumulative Penetration (ng/cm<sup>2</sup>)

Minutes	Swatch 1	Minutes	Swatch 2	Minutes	Swatch 3
2	0	5	0	8	0
32	4	35	10	38	32
62	16	65	39	68	141
92	34	95	85	98	325
122	54	125	142	128	567
152	74	155	202	158	840
182	93	185	264	188	1130
212	111	215	327	218	1424
242	129	245	389	248	1715
272	144	275	449	278	2007
302	156	305	507	308	2291
332	167	335	561	338	2562
362	180	365	615	368	2826
392	195	395	671	398	3087
422	209	425	725	428	3349
452	224	455	779	458	3602
482	239	485	832	488	3848
512	253	515	883	518	4086
542	266	545	933	548	4317
572	279	575	981	578	4545
602	292	605	1027	608	4764
632	304	635	1072	638	4973
662	315	665	1116	668	5172
692	326	695	1158	698	5366
722	336	725	1199	728	5554
752	347	755	1240	758	5734
782	356	785	1279	788	5910
812	366	815	1317	818	6079
842	376	845	1355	848	6249
872	385	875	1392	878	6417
902	394	905	1428	908	6579
932	403	935	1464	938	6739
962	412	965	1500	968	6898
992	420	995	1534	998	7049
1023	429	1026	1568	1029	7197
1053	437	1056	1602	1059	7339
1083	444	1086	1634	1089	7479
1113	452	1116	1666	1119	7619
1143	460	1146	1698	1149	7756
1173	468	1176	1729	1179	7889
1204	475	1207	1760	1210	8020
1234	482	1237	1789	1240	8147
1264	489	1267	1819	1270	8271
1294	496	1297	1848	1300	8395
1324	503	1327	1877	1330	8519
1354	509	1357	1905	1360	8640
1385	515	1388	1932	1391	8757
1415	521	1418	1958	1421	8872

## Appendix C